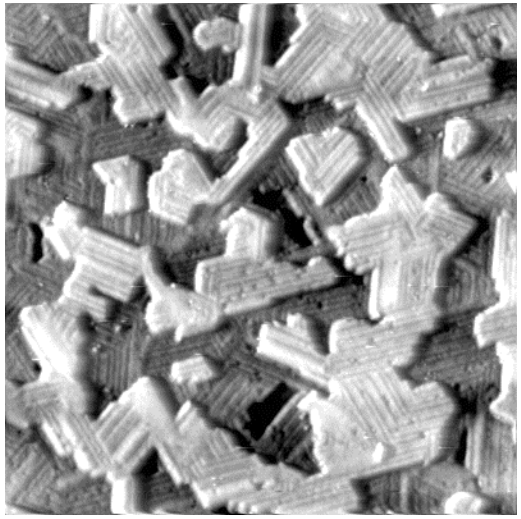
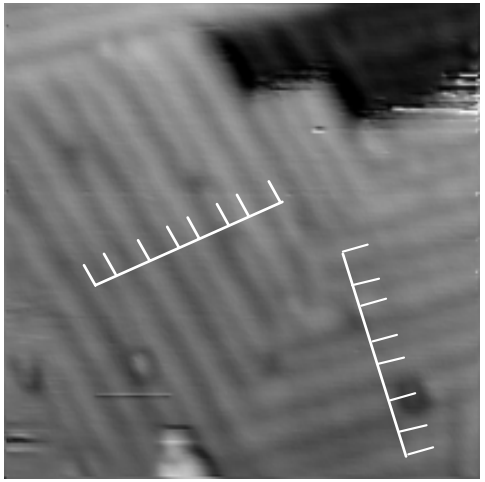
Studies of Weakly Adsorbed Layers

Renee Diehl and Milton Cole, Penn State University, DMR-0208520

Quasicrystal surfaces offer the unique opportunity to study the effects of aperiodicity on the properties of adsorbed thin films. This project uses low-energy electron diffraction, scanning tunneling microscopy and state-of-the-art computational methods to study this problem.

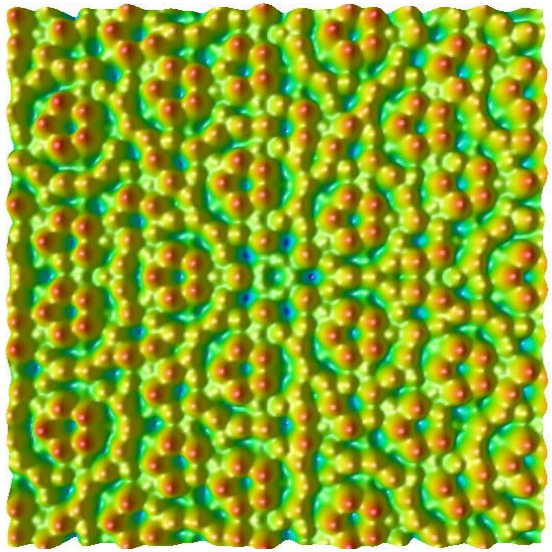


The figure to the left shows an STM image of a thin copper film on top of a Al-Pd-Mn substrate. The Cu grows layer-by-layer. The structure within the layer shows rows whose spacing follows the Fibonacci sequence.



Magnified image of the row structure, showing the Fibonacci spacings. This structure is pseudomorphic with the substrate even after 20 layers of Cu.

Understanding this growth is a current challenge that is being approached computationally using simple model systems.



Calculated minimum potential energy surface for Xe interacting with a 5-fold quasicrystal surface.

We have carried out experimental and theoretical studies of atoms adsorbed on quasicrystal surfaces. Quasicrystals are well-ordered alloy materials that are not periodic, and they often have "forbidden" symmetries, such as the five-fold symmetry seen in the color figure on this page. The challenge is to grow single-species overlayers on these substrates that also are aperiodic and have "forbidden" symmetries. The possibility of quasiperiodic nano-ordered films and arrays open up many possibilities for tuning properties in new electronic, magnetic and photonic materials.

Although we have now tried many different adsorbates on quasicyrstal surfaces, the only example of a quasicrystalline film is for copper. The Cu film shown here has a substrate-induced aperiodic row structure that persists up to at least 100 layers. This is the first example of pseudomorphic growth on a quasicyrstal substrate and was recently reported by us in Physical Review Letters (Phys. Rev. Lett. 92, 135507 (2004).)

Because the pseudomorphic film is a metal, it is difficult to calculate the precise interactions between the quasicrystal and a metal film. Therefore we have started with a simpler model to calculate the interaction, that of a rare gas adsorbate, Xe. Simulations for this model will be performed and the result compared to experimental results before we move to more complex models.

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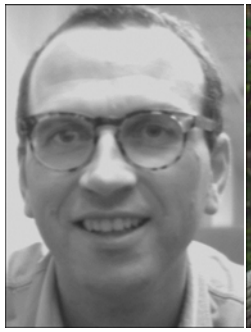
This program is part of an international collaborative group that studies the properties of surfaces and weakly adsorbed layers on quasicrystals. It consists of researchers in the US, UK, Finland and Germany. Some of the players are pictured here.

UK



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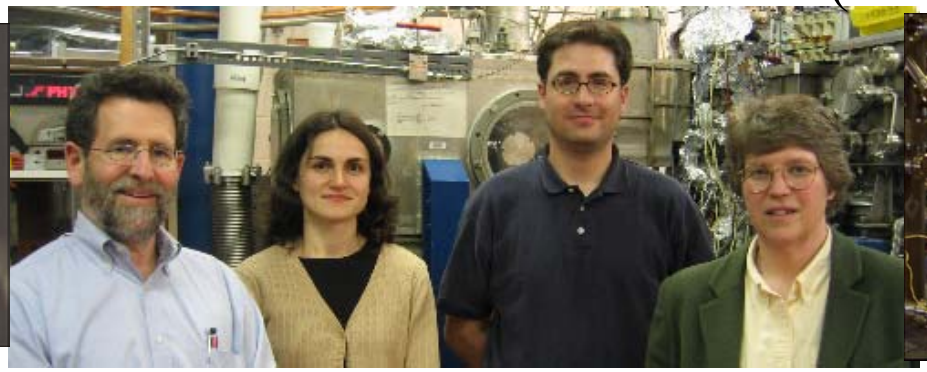

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